Chapter 14
Wireless IEEE 802.11–Based Networking Approaches for Industrial Networked Systems

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ABSTRACT

During the last few years, the demand for Real-Time (RT) communication has been steadily increasing due to a wide range of new applications. Remarkable examples are VoIP (Voice over IP) and Networked Control Systems (NCS). For such RT applications, the support of timely communication services is one of the major requirements. The purpose of this chapter is to survey the state-of-the-art on RT communication in CSMA-based networks and to identify the most suitable approaches to deal with the requirements imposed by next generation communication systems. This chapter focuses on one of the most relevant solutions that operate in shared broadcast environments, according to the CSMA medium access protocol, the IEEE 802.11 standard. From this survey, it becomes clear that traditional CSMA-based networks are not able to deal with the requirements imposed by next generation communication systems. More specifically, they are not able to handle uncontrolled traffic sources sharing the same broadcast environment.

1. INTRODUCTION

This chapter surveys the state-of-the-art on Real-Time (RT) communication in wireless CSMA-based networks. One of the main objectives is to show that traditional RT communication approaches for CSMA-based networks are not able to deal with the requirements imposed by next generation communication systems. More specifically, they are not able to handle uncontrolled traffic sources sharing the same broadcast environment. Similar conclusions could be drawn for other CSMA-based protocols, such as IEEE 802.15.4 (one of the most widespread PAN protocols) or CAN (commonly

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used in automotive and industrial applications). However, such protocols are out of the scope of this chapter, as we are focusing on CSMA-based wireless LAN protocols.

Another purpose of this chapter is to identify the main design guidelines that will enable the support of RT communication services in CSMA-based networks, even when the communication environment is shared with uncontrolled traffic sources. As an outcome of this RT communication survey, a RT communication framework is defined, which fulfills the requirements imposed by typical RT applications. It is traditionally considered that RT communication services can be classified according to the degree of RT guarantees into hard and soft RT groups. Hard RT applications require communication services with predictable and bounded response times, and violations of these response times may have severe consequences. Instead, soft RT applications can tolerate some losses of temporal deadlines. For instance, a RT control application can tolerate occasional losses of the control law updates, especially if the control law has been modified to account for those lost updates (Ramanathan, 1999). However, this type of applications is usually less resilient against jitter on the control law updates. In the case of a NCS, it is of utmost importance to have a nearly constant average communication delay and low jitter, whatever the behavior of the communication environment.

The major challenge concerning the design of protocol architectures for CSMA-based networks is that the channel is a shared resource. Therefore, there is the need to prioritize RT data messages, when the communication infrastructure is shared with external traffic sources (Sauter & Vasques, 2006). Thus, the access to this shared resource needs to be coordinated either centrally or in a distributed manner (Tavli & Heinzelman, 2006). According to the ISO/OSI model, this coordination task is performed by Medium Access Control (MAC) protocols. Actually, the MAC protocol is the key issue in any broadcast random access network. This chapter surveys one of the most relevant random access protocol in wireless environments: the IEEE 802.11 standard protocol[1]. A relevant characteristic of this protocol is the use of the Carrier Sense Multiple Access (CSMA) mechanism to manage the medium access. Its main drawback is the non-determinism of the probabilistic contention resolution algorithm.

The demand for high performance industrial wireless networking will increase significantly in the next few years. This is a consequence of recent technology developments that demand wireless access in office environments, in public hot-spots and in domestic environments. Presently, significant efforts are being made to move from wired to wireless networks (Jonsson & Kunert, 2009; Willig, Matheus, & Wolisz, 2005). Therefore, it is reasonable to expect that in the near future, the widespread availability of wireless solutions will generate a similar de facto standard for industrial wireless communications. Within this context, the IEEE 802.11 family of protocols is one of the main contenders to become a de facto standard for industrial wireless communications (Sauter, 2010). Nevertheless, it has received only limited coverage in this research community (Willig, 2008). On the one hand, this family of protocols reveals shortcomings in the prioritization of real-time data messages. On the other hand, it is easily able to replace industrial Ethernet solutions in a transparent way, implementing the two lowest layers of the ISO/OSI model, providing all the required functionalities to enable the support of the Internet Protocol (IP) that is virtually the basis for every application over Ethernet networks. Within this context, the IEEE 802.11 family of protocols is one of the main contenders to become a *de facto* standard for industrial wireless communications